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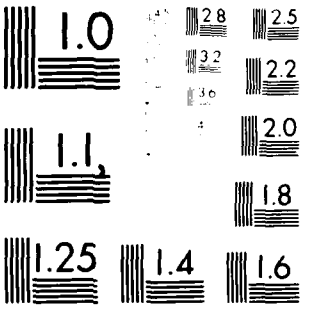

FINAL SCIENTIFIC REPORT

to the

AIR FORCE OF SCIENTIFIC RESEARCH

THE STRUCTURE AND PROPERTIES OF POLYMERIC MATERIALS

AFOSR 77-3293

FOR THE PERIOD

1 FEBRUARY 1977 to 30 SEPTEMBER 1981

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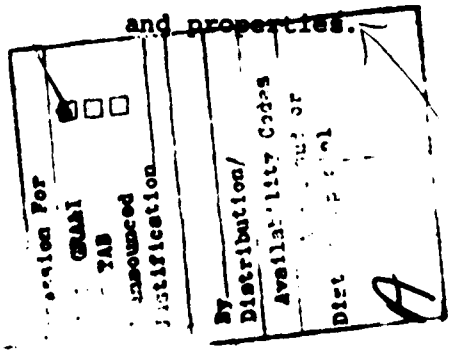
Report submitted March 26, 1982

SUMMARY OF RESEARCH PROGRESS

Research on the theory of liquid crystalline systems has been continued with special emphasis on systems of semiflexible polymer chains. Experiments on low molecular analogs have been carried out with the primary object of assessing the effects of anisotropic intermolecular forces in effecting stabilization of an anisotropic phase. It has been demonstrated that anisotropy of the molecular polarizability, which can be evaluated by optical measurements of depolarized Rayleigh scattering (DRS), is directly responsible for the effect. The density of the fluid has been found to play an important role, not hitherto recognized. It must be taken into account in any quantitative treatment of liquid crystallinity in low molecular substances at high temperatures.

The theory of rubber elasticity of real polymeric networks has been refined and generalized. In its revised form the theory gives a good account of the relationship of stress to strain for all strains, including biaxial deformations, throughout experimentally accessible ranges. The principal parameter required, apart from the degree of interlinking that characterizes the network structure, appears to be related to the degree of interpenetration in the network. This parameter, too, may be subject to evaluation, also from molecular characteristics. Thus, the theory provides an essential link between molecular structure and properties.



PAPERS PUBLISHED OR SUBMITTED
1 FEBRUARY 1977 to 30 SEPTEMBER 1981

(Asterisks denote investigations supported by AFOSR)

*1. "Analysis of Nuclear Magnetic Resonance Spectra of Protons in Predominantly Isotactic Polystyrene," D. Y. Yoon and P. J. Flory, Macromolecules, 10, 562 (1977).

2. "Small-angle Neutron Scattering by Semicrystalline Polyethylene," D. Y. Yoon and P. J. Flory, Polymer, 18, 509 (1977).

*3. "Theory of Elasticity of Polymer Networks. The Effect of Constraints on Junctions," P. J. Flory, J. Chem. Phys., 66, 5720 (1977); also Rubber Chem. and Tech., 52, No. 1, 110 (1977).

4. "Concept and Innovation in Polymer Science," P. J. Flory, Perkin Medal Lecture, New York, N. Y., 18 February 1977, Chemistry and Industry, 21 May 1977, pp. 369-372.

*5. "Separation of Collision-Induced from Intrinsic Molecular Depolarized Rayleigh Scattering. Optical Anisotropy of the C-Cl Bond," C. W. Carlson and P. J. Flory, J. Chem. Soc., Faraday Trans. II, 73, 1505 (1977).

*6. "Optical Anisotropy of Polystyrene and Its Low Molecular Analogues," U. W. Suter and P. J. Flory, J. Chem. Soc., Faraday Trans. II, 73, 1521 (1977).

7. "Optical Anisotropies of para-Halogenated Polystyrenes and Related Molecules," E. Saiz, U. W. Suter and P. J. Flory, J. Chem. Soc., Faraday Trans. II, 73, 1538 (1977).

*8. "Dipole Moments of Poly(p-chlorostyrene) Chains," E. Saiz, J. E. Mark and P. J. Flory, Macromolecules, 10, 967 (1977).

9. "The Molecular Theory of Rubber Elasticity," P. J. Flory, Contemporary Topics in Polym. Sci., Vol. 2, Ed. E. M. Pearce and J. R. Schaefgen, Plenum Publ. Corp., New York, 1977, pp. 1-18.

*10. "Statistical Thermodynamics of Macromolecular Liquids and Solutions," P. J. Flory, Ber. Bunsenges. Phys. Chem., 81, 885 (1977).

11. "Molecular Morphology in Semicrystalline Polymers," P. J. Flory and D. Y. Yoon, Nature, 272, 226 (1978).

*12. "Rubber Elasticity in the Range of Small Uniaxial Tensions and Compressions. Results for Poly(dimethylsiloxane)," B. Erman and P. J. Flory, J. Polym. Sci.: Polym. Phys. Ed., 16, 1115 (1978).

*13. "Theory of Elasticity of Polymer Networks. II. The Effect of Geometric Constraints on Junctions," B. Erman and P. J. Flory, J. Chem. Phys., 68, 5363 (1978).

14. "Chemistry, Macromolecules, and the Needs of Man," P. J. Flory, Pure & Appl. Chem., 50, 255 (1978).

15. "Small Angle Neutron Scattering by n Alkane Chains," D. Y. Yoon and P. J. Flory, J. Chem. Phys., 69(6), 2536 (1978).

*16. "Statistical Thermodynamics of Mixtures of Rodlike Particles. 1. Theory for Polydisperse Systems," P. J. Flory and A. Abe, Macromolecules, 11, 1119 (1978).

*17. "Statistical Thermodynamics of Mixtures of Rodlike Particles. 2. Ternary Systems," A. Abe and P. J. Flory, Macromolecules, 11, 1122 (1978).

*18. "Statistical Thermodynamics of Mixtures of Rodlike Particles. 3. The Most Probable Distribution" P. J. Flory and R. S. Frost, Macromolecules, 11, 1126 (1978).

*19. "Statistical Thermodynamics of Mixtures of Rodlike Particles. 4. The Poisson Distribution," R. S. Frost and P. J. Flory, Macromolecules, 11, 1134 (1978).

*20. "Statistical Thermodynamics of Mixtures of Rodlike Particles. 5. Mixtures with Random Coils," P.J. Flory, Macromolecules, 11, 1138 (1978).

*21 "Statistical Thermodynamics of Mixtures of Rodlike Particles. 6. Rods Connected by Flexible Joints," P. J. Flory, Macromolecules, 11, 1141 (1978).

22. "The Elastic Free Energy of Dilation of a Network," P. J. Flory, Macromolecules, 12, 119 (1979).

*23. "Relationship of Stress to Uniaxial Strain in Crosslinked Poly(Dimethylsiloxane) over the Full Range from Large Compressions to High Elongations," H. Pak and P. J. Flory, J. Polym. Sci.: Polym. Phys. Ed., 17, 1845 (1979).

24. "Molecular Theory of Rubber Elasticity," P. J. Flory, Polymer, 20, 1317 (1979).

*25. "Theory of Systems of Rodlike Particles. I. Athermal Systems," P. J. Flory and G. Ronca, Mol. Cryst. Liq. Cryst., 54, 289 (1979).

*26. "Theory of Systems of Rodlike Particles. II. Thermotropic Systems with Orientation-dependent Interactions," P. J. Flory and G. Ronca, Mol. Cryst. Liq. Cryst., 54, 311 (1979).

27. "Molecular Structure, Conformation and Properties of Macromolecules," P. J. Flory, Pure & Appl. Chem., 52, 241 (1980).

28. "Structural Geometry and Torsional Potentials in p-Phenylene Polyamides and Polyesters," J. P. Hummel and P. J. Flory, Macromolecules, 13, 479 (1980).

*29. "Moments of the End-to-End Vectors for p-Phenylene Polyamides and Polyesters," B. Erman, P. J. Flory, and J. P. Hummel, Macromolecules, 13, 484 (1980).

30. "Interphases of Chain Molecules: Monolayers and Lipid Bilayer Membranes," K. A. Dill and P. J. Flory, Proc. Natl. Acad. Sci. USA, 77, No. 6, 3115 (1980).

*31. "Elastic Modulus and Degree of Cross-Linking of Poly(Ethyl Acrylate) Networks," B. Erman, W. Wagner, and P. J. Flory, Macromolecules, 13, 1554 (1980).

32. "Introductory Lecture: Levels of Order in Amorphous Polymers," P. J. Flory, Faraday Discuss. Chem. Soc., 68, 14 (1979).

33 "Molecular Morphology in Semicrystalline Polymers," D. Y. Yoon and P. J. Flory, Faraday Discuss. Chem. Soc., 68, 288 (1979).

34. "Phase Equilibria in Thermotropic Liquid Crystalline Systems," M. W. Warner and P. J. Flory, J. Chem. Phys., 73, 6327 (1980).

35. "Molecular Organization in Micelles and Vesicles," K. A. Dill and P. J. Flory, Proc. Natl. Acad. Sci. USA, 78, No. 2, 676-680 (1981).

36. "Structural Regularity and Crystallinity in Macromoleculus," P. J. Flory, "Structural Order in Polymers," ed: F. Ciardelli, P. Guisti, Pergmon Press Oxford (1981).

*37. "Statistical Thermodynamics of Mixtures of Semirigid Macromolecules: Chains with Rodlike Sequences at Fixed Locations," R. R. Matheson and P. J. Flory, Macromolecules, 13, 954-960 (1981).

38. "Intermediate Angle Scattering Functions and Local Chain Configurations of Semicrystalline and Amorphous Polymers, D. Y. Yoon and P. J. Flory, Polymer Bulletin, 4, 693-698 (1981).

39. Direction of the Dipole Moment in the Ester Group," E. Saiz, J. P. Hummel and P. J. Flory, The Journal of Physical Chemistry, and M. Plavsic, 85, 3211-3215.

40. "Optical Anisotropies of Aliphatic Esters," P. J. Flory, E. Saiz, B. Erman, P. Irvine and J. P. Hummel, The Journal of Chemistry, 85, 3215-3221 (1981).

*41. "Elastic Activity of Imperfect Networks," P. J. Flory, Macromolecules, in press

*42. "Theory of Elasticity of Polymer Networks," P. J. Flory and B. Erman, submitted for publication.

*43. "Relationships Between Stress, Strain and Molecular Constitution of Polymer Networks. Comparison of Theory with Experiments," B. Erman and P. J. Flory, submitted for publication.

44. "Molecular Theory of Liquid Crystals," P. J. Flory, to be published in "Polymer Liquid Crystals," ed. by A. Ciferri, et al.

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Research on the theory of liquid crystalline systems has been continued with special emphasis on systems of semiflexible polymer chains. Experiments on low molecular analogs have been carried out with the primary object of assessing the effects of anisotropic intermolecular forces in effecting stabilization of an anisotropic phase. It has been demonstrated that anisotropy of the molecular polarizability, which can be evaluated by optical measurements of depolarized Rayleigh scattering (DRS), is directly responsible for the effect. The density of the fluid has been found to play an important role, not hitherto recognized. It must be taken into account in any quantitative treatment of liquid crystallinity in low molecular substances at high temperatures.

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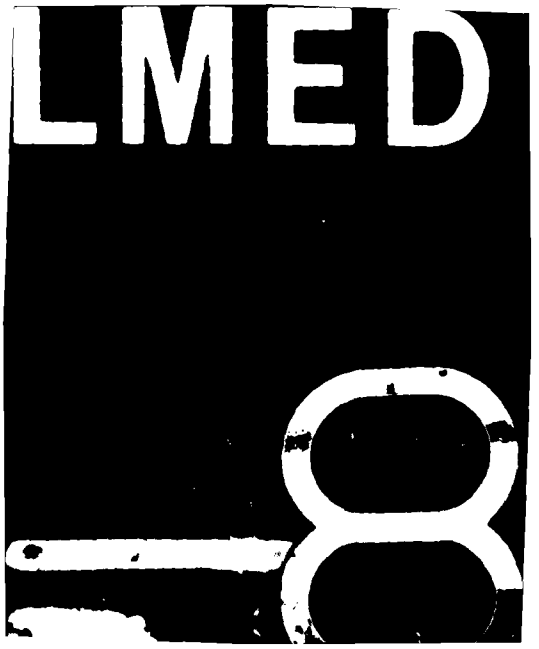
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